Soil erosion by wind

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to control soil drifting

- Understand the cause of drifting and what drifting does to productive farmland.
- Use one or more of the following long-term protective practices:
  - Strip farming,
  - Contour farming,
  - Planting field shelterbelts,
  - Reducing or eliminating summer fallow.
- Use one or more of the following short-term protective practices:
  - Growing cover crops — seeded or volunteer,
  - Trash-cover farming, in which you maintain adequate trash protection, avoid unnecessary soil pulverization, use suitable equipment.
- Use emergency control measures if drifting starts. Don't wait until damage has been done.

foreword

This publication was prepared by a committee consisting of the following people, who conducted experimental work on various phases of the complex problem of controlling soil erosion by wind:

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soil erosion by wind cause, damage, and control

introduction

Soil erosion by wind occurred on the prairies of Western Canada soon after the land was brought under cultivation. Frequent outbreaks led to the adoption of strip cropping in southern Alberta about 1918. Severe and widespread drifting during the period from 1931 to 1938 led to intensive efforts to adopt practices that provided a measure of control. Soil drifting has occurred periodically since that time. The drought experienced on the prairies during the late fifties and early sixties was accompanied by many isolated outbreaks. The drifting was confined mostly to individual farms and some fields were severely eroded.

Soil erosion by wind is usually associated with the practice of summerfallowing, but it is not necessarily confined to fallowed fields. It can occur during the spring when land is not protected by young crops. It also occurs on irrigated land when annual crops have been harvested and the land lies unprotected until the next crop has attained some growth. The hazard of soil drifting is greatest on the open prairies of Alberta, Saskatchewan, and Manitoba. These areas generally include the Brown, Dark Brown, and some parts of the Black soil zones, but drifting may also occur in other parts of the prairies.

Figure 1. Wind has removed valuable topsoil from this field.

how soil drifting occurs

Soil drifting is caused by wind blowing across an unprotected soil surface that is dry, loose, and finely granulated. Dust particles less than 0.1 millimeter in diameter, once dislodged, are lifted into the air and carried in suspension for many miles. Coarser particles (about 0.1 to 0.5 millimeter) are lifted upward a distance and then travel forward and downward at high speed. They strike the soil surface, breaking down clods and surface crusts and dislodging other particles. Larger particles (about 0.5 to 1.0 millimeter) creep and roll along the surface. Winds of extremely high velocity may move particles larger than 1.0 millimeter but those 0.5 millimeter in diameter or smaller are the most erodible.

Drifting usually starts on exposed knolls in the field, tracks in which implement wheels have crushed clods, and corners of fields that have been excessively cultivated. The abrasive action of soil blown from these focal points soon changes a resistant surface to one that may drift. The process is cumulative, and drifting downwind from the focal point can become general in a short time. Soil particles are deposited behind ridges, clumps of plant residue, and other barriers or are carried off the field. The surface gradually becomes dotted with hummocks of sand. Winds of lower velocity than that necessary to start erosion can continue the movement of soil.

damage

Damage caused by the wind erosion of soil takes many forms. Drifting over a period of years depletes fertility. This is demonstrated by the fact that the fine dust particles moved from a field contain up to twice as much nitrogen, organic matter, and phosphorus as material remaining. In some areas a loss of 2 inches of topsoil has noticeably reduced yields. In one field study, over a 7-year period, barley averaged 28 bushels per acre where topsoil had not been removed and 10 bushels where topsoil had been completely removed. The greatest difference in yield occurred in years when moisture was in good supply.

Drifting also results in a gradual change in the texture of the cultivated layer. Studies conducted in Western Canada revealed that the sorting action of the drifting process removed up to one half of the silt and one third of the clay from some sandy soils. Losses of about one fifth of the silt and smaller quantities of clay particles were measured on severely eroded medium-textured soils. Heavy clay soils were least affected by sorting action. Reduced moisture-holding capacity of the cultivated layer resulted from the loss of the silt and clay particles, and the soil was more easily eroded.

The removal of drift soil from a fence line, a roadside drainage channel, an irrigation ditch, or around farm buildings is costly. Drift soil deposited in farmstead shelterbelts can ruin the plantings, which may take years to replace. Crops can be blown out completely or the yield reduced by the sandblast effect of drift soil (see Figure 2). Reseeding is expensive and yields may be reduced.

Figure 2. Wind removed enough soil from this field to expose plant roots (see inset) and kill out the crop.

factors that influence erosion

The following factors influence the beginning, extent, and eventual control of soil drifting.

- Wind—The hazard of soil erosion by wind increases as wind velocity increases. High velocity winds that blow for several hours or intermittently for several days are the most frequent cause of drifting.
- Soil moisture—Moist surface soil does not drift. Tillage may expose moist soil, which, if pulverized, resists drifting only until it dries out. Moisture from rain or snow that thoroughly soaks the surface consolidates the soil. Except on drift sand, a crust is usually formed as the surface dries, and this crust prevents drifting until it is broken. A small amount of moisture does not consolidate and crust the soil surface, hence drifting is stopped only until the surface dries out.
- Cloddy surface—A field on which at least half of the surface clods are larger than 1.0 millimeter (about 1/25 inch) resists most strong winds. A field that contains two thirds or more of the erodible granules (less than 1.0 millimeter) on the surface is eroded by a light wind (see Figure 3). Clods are broken down by tillage, by crushing under implement wheels, by abrasion, and by weathering.

Soil texture influences the resistance of clods to breakdown in size. Fine sand and fine sandy loam soils form clods only when cultivated while

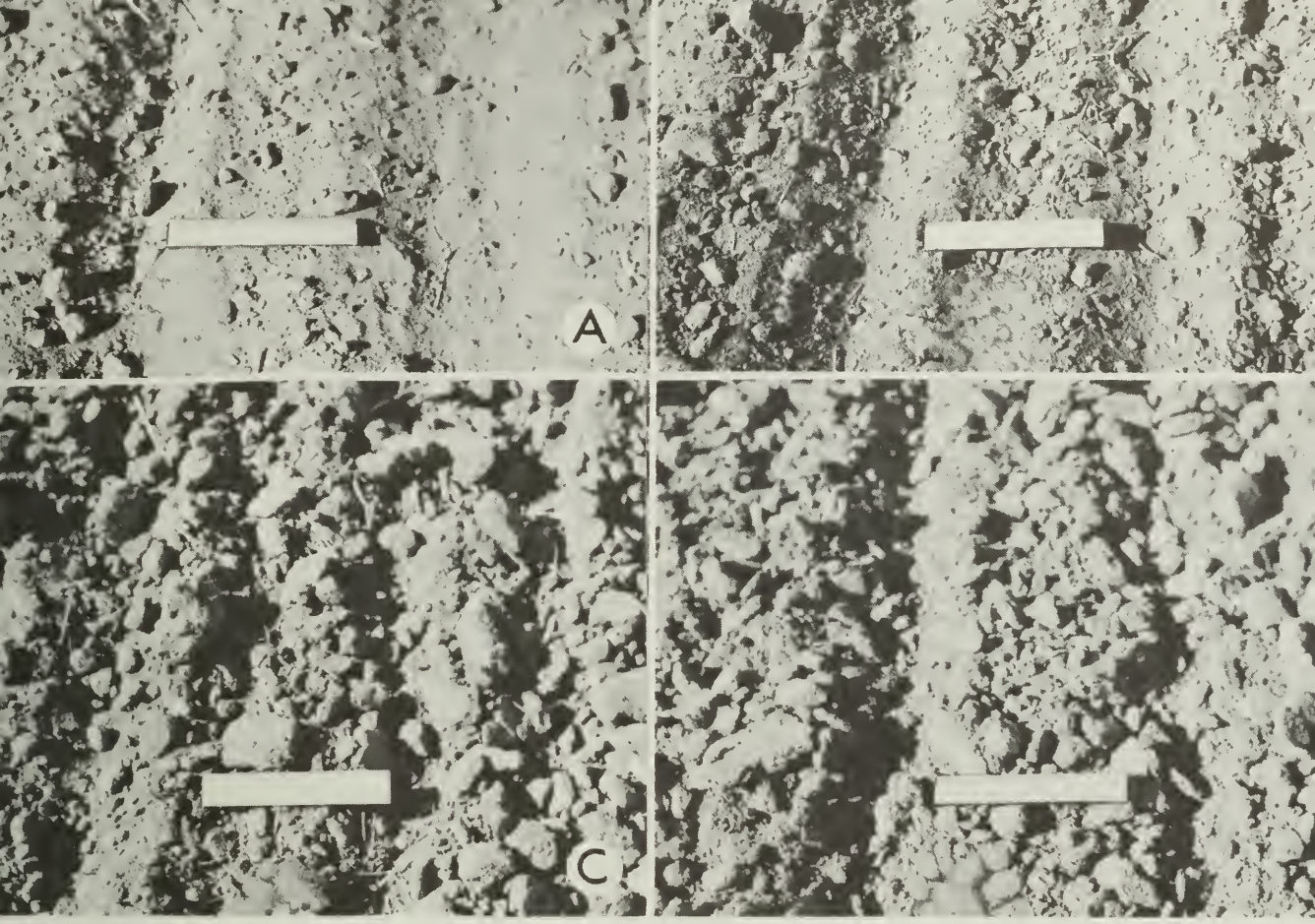

Figure 3. A cloddy surface prevents erosion. Clod size in each inset can be compared with the 6-inch ruler. (A) 75 percent fine clods (highly erodible); (B) 60 percent fine clods (moderately erodible); (C) 45 percent fine clods (resists most winds); (D) 25 percent fine clods (resists extreme winds). *(See Figure 13, page 25).*

moist and firm. Such clods are readily broken down by heavy rainfall and by drying while frozen. Clay soils form clods when cultivated but crumble readily by drying when frozen. Loam, silt loam, clay loam, and silty clay loam soils form clods when tilled. These clods are more resistant to breakdown than clay or sandy clods. Measurements of clod breakdown by weathering during the winter indicate that on all but the most resistant soils the freeze-drying and other weathering processes can change a resistant soil surface to one that is highly erodible. The change in erodibility over winter is dependent upon soil type, weather conditions, and soil crusting.

- Vegetative cover—Plant residue, or trash cover, and growing crops protect soil from wind. The degree of protection depends on the quantity and type of cover.
- Field size—The larger the field the greater the hazard of soil drifting.
- Topography and wind barriers—Erosion usually starts on unprotected knolls. Wind barriers such as field shelterbelts reduce the hazard of soil erosion.

control measures

Measures for the prevention of erosion by wind are of two types. First, there are routine practices used every year to prevent the start of drifting: trash-

cover farming, strip cropping, growing cover crops, rotating crops, and providing shelterbelts. Secondly, there are proven emergency control measures used to stop or to reduce soil movement once drifting has started. A successful program must utilize both types.

TRASH COVER FARMING

Trash cover farming may be defined as farming to maintain an adequate protective cover of plant residue and an erosion-resistant cloddy surface whenever the soil is not protected by a growing crop.

TRASH COVER

Trash cover prevents erosion by reducing wind velocity at the surface of the soil. If drifting starts, trash cover traps moving soil particles and thus reduces the intensity of drifting. Generally, the greater the quantity of trash on the surface the better the protection provided. Upright trash (Figure 5) is considerably more effective than an equal quantity of flattened trash (Figure 4).

The quantity of trash required to protect soil from wind varies with wind velocity, the amount of erodible material on the surface, and other factors (see page 8). About 1,500 pounds per acre of erect or semierect trash provides protection for medium-textured soils. Larger quantities are required to adequately protect sandy and heavy clay soils. Lesser quantities provide partial protection but high velocity winds may cause drifting. In dry areas, and during periods of drought in the moister areas, total trash production seldom exceeds that required to protect the soil. Every effort should be made to conserve this trash for soil protection.

The total weight of the standing stubble and combine straw produced with each pound of grain is expressed as the straw/grain ratio. The ratio varies from year to year and particularly when a crop produced under good growing conditions is compared with one produced under conditions of drought or disease. The ratio does provide a useful guide for estimating the quantity of material available as trash cover. Also, visual estimates can be made by comparing trash cover on a field with the amounts illustrated in Figures 4 and 5.

Straw/grain ratios for wheat have been determined at several experimental farms in Western Canada. The normal range of values for some major soil zones is given below. Average values are also given for oats, rye, and barley. Ratios for these crops will likely vary in different soil zones in a manner similar to wheat.

CROP	SOIL ZONE	POUNDS OF RESIDUE	POUNDS OF GRAIN
Wheat	black and thin black	2.0 to 1.5	1.0
	dark brown	1.6 to 1.0	1.0
	brown	1.4 to 1.0	1.0
Oats		1.5	1.0
Rye		1.5	1.0
Barley		1.0	1.0

Residue from crops such as flax, mustard, rape, and sunflowers provides less erosion protection than residue from cereal crops (see "Specialty Crops," page 25).

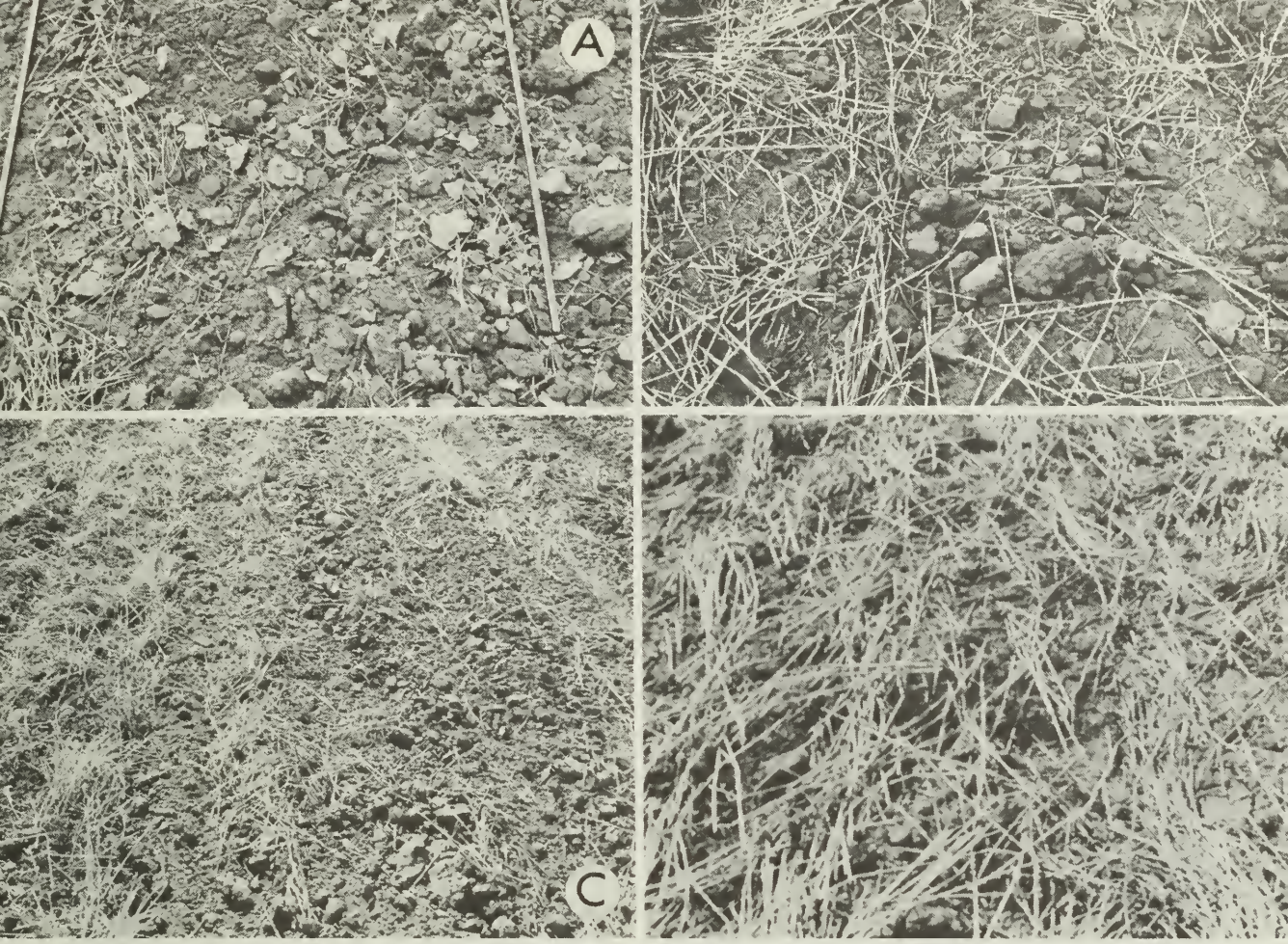

Figure 4. Various quantities of cereal residue (trash cover). (A) 500 pounds per acre (note square-yard frame); (B) 1,000 pounds per acre; (C) 1,500 pounds per acre; (D) 2,000 pounds per acre. (See also Figure 5).

Figure 5. This field is well protected in the fall of the year by 1,800 pounds of semierect trash cover per acre. Note that the soil clods have slaked into an erodible condition and only the trash cover remains to prevent erosion

CLOD PRODUCTION

The first operation of a fallow season is normally performed when the soil is firm and the resulting cloddy surface is usually resistant to erosion. Generally, subsequent operations in the loosened soil breaks down clods unless the soil has been consolidated by rain and has subsequently dried out. Packing moist soil by machines or by tractor wheels consolidates soil. If the soil then becomes dry, further tillage produces wind-resistant clods. Tilling immediately after packing seldom produces nonerodible clods unless moisture content is at the sticky point.

HARVESTING EQUIPMENT

Trash cover farming begins with the harvesting operation. When the swather is used, set the table to leave as tall a stubble as will hold the swath. When harvesting by the direct-cut method, set the combine table to leave a reasonably tall stubble (about 12 inches). Use the straw spreader on the combine. Uniformly spread straw seldom causes plugging of tillage implements. Windrowed and piled straw can cause considerable difficulty. In heavy crops, (for example, 30 bushels per acre or more of wheat) use the combine straw chopper attachment to reduce straw length and to spread straw. It is seldom necessary to chop straw fine. Finely chopped straw, which is easily buried by tillage, is not as effective for erosion control as long straw. When picking up double swaths from all but the very light crops, it is advantageous to use the chopper. The chopper attachment is more effective than the spreader for breaking down flax straw.

TILLAGE EQUIPMENT

Tillage implements differ in their ability to produce clods during primary tillage in a firm soil. Subsequent tillage and summer rainfall affect cloddiness and offset the differences that exist following primary tillage. During normal summer fallowing avoid excessive tillage speed when the soil pulverizes readily.

Tillage machines differ widely in their capacity to conserve or bury surface trash. According to studies conducted at various experimental farms in Western Canada the *average* amount of trash from cereal crops buried by each tillage operation with some commonly used machines is as follows:

TILLAGE MACHINE	PERCENT REDUCTION BY EACH TILLAGE OPERATION
Subsurface cultivators	
wide-blade cultivator (sweeps 36 inches or wider)	10
sweep cultivator (sweeps 24 to 32 inches)	10
rod weeder (used for secondary tillage)	10
Mixing implements	
heavy-duty cultivator (16-inch or 18-inch shovels) with attached rod weeder	15
heavy-duty cultivator (16-inch or 18-inch shovels)	20
discer and one-way disc (24-inch to 26-inch pans)	50
discer (18-inch to 22-inch pans)	40
Inverting implements	
moldboard plow	100

Straw-to-grain ratios (see page10) can be used to estimate the original

quantity produced, and the figures for trash reduction by tillage (above) can be used to estimate the quantity of trash conserved at the end of the fallow season. Use the average reduction figure and the number of tillage operations anticipated or conducted to estimate surface trash conserved for protection of the soil. Relate this to the amount required for protection.

Subsurface cultivators — The wide-blade cultivator, the sweep machine, and the rod weeder conserve the most trash of any of the commonly used machines, regardless of stubble height. These machines are equally effective on tall or short stubble. More trash is buried during primary tillage than during secondary operations. If the rod weeder, the wide-blade cultivator, or the sweep machine is used on a field previously tilled with a disc machine, some buried trash (10 to 15 percent) is often lifted to the surface. Very shallow tillage (less than 3 inches) flattens and loosens trash and granulates soil more than deep tillage (3 to 4 inches). Shallow tillage with the rod weeder, however, on a field previously cultivated with a heavy-duty cultivator levels ridges but buries trash in the process. Subsurface cultivators, when used for primary tillage during cool weather and in a fairly moist soil, do not kill weeds as effectively as disc machines. Annual and winter-annual weeds that have established a well-developed root system may re-establish and continue to grow. An early second operation may be needed to completely kill these weeds. Early spring cultivation with subsurface cultivators kills weeds before an extensive root system develops and before they use stored moisture.

The heavy-duty cultivator, if equipped with a rod-weeder attachment, conserves trash nearly as well as other cultivators. Avoid operating the attached rod at a shallow depth. Shallow operation (less than 3 inches) causes plugging, burial and excessive loosening of trash, and unnecessary pulverizing of soil. The heavy-duty cultivator when used without the rod attachment buries trash to a greater extent than other cultivators. Trash burial varies from almost nil to 50 percent, depending on operating conditions. Severe burial may occur during primary tillage or at other times when the soil is firm and moist to the sticky point. At this stage the shovels do not scour properly. Under these conditions avoid operating at a speed higher than about 3 to 4 miles per hour. Operate the cultivator with the frame level and with the shovels at a depth of 3 to 4 inches for best trash conservation. Carefully operated, the heavy-duty cultivator conserves trash effectively.

Disc machines—The one-way disc, discer, tandem disc, and offset disc are similar in their effects on trash conservation. They bury very short and very tall stubble more than stubble of intermediate height (8 to 12 inches). Best conservation is obtained during primary tillage when the stubble is just tall enough to clear or to brush against but not to project more than an inch or two above the spacer spool on the arbor bolt when the machine is at operating depth. Trash burial increases as depth of tillage is increased. Operate the one-way disc or the discer at a moderate depth (3 to 4 inches, depending on disc diameter), at a moderate speed (3 to 4 miles per hour), and at as wide a cutting width as

is consistent with good weed control. When the disc machine is used at full depth for controlling weeds, up to 60 percent of the trash is buried. Secondary tillage with a subsurface cultivator moves some protective trash to the surface. During summer-fallowing operations disc machines must be used sparingly if trash is to be retained on the surface.

The moldboard plow buries trash completely and is not used in trash-cover farming. It produces clods of greater erosion stability than other tillage implements and is used for emergency erosion control in some areas (see page 19).

SEEDING EQUIPMENT

Seeding equipment is available that will handle most situations met in a trash-cover farming program. In research studies at several locations in Western Canada the following facts were discovered:

- Up to 3,000 pounds per acre of trash on a field after seeding protects the soil and does not reduce yields.
- Important differences in yield seldom occur when two or more seeding machines of different design are compared, provided that the machines perform satisfactorily under the prevailing seedbed conditions.
- Packing after seeding is an essential operation when large quantities of trash exist.
- Drills differ in their capacity to provide satisfactory seed placement under different seedbed conditions.

The double-disc and the single-disc drill, often mounted on a press-wheel carriage, are used for seeding fields covered with limited quantities of trash. These drills operate satisfactorily through quantities of 1,500 to 2,000 pounds of well-spread trash per acre. Greater quantities may cause plugging and the openers may not cut through trash to place seed into firm, moist soil. The openers may fail to penetrate to moisture under severe drought conditions when moisture is located deeper than 3 to 4 inches.

The one-way disc and the discer (*one-way flexible disc-harrow*) equipped with a seed-box attachment can be used successfully where trash is not excessive (up to 4,000 pounds). On medium-textured soils the disc provides an erosion-resistant cloddy surface if the soil is firm. The use of a suitable packer is essential behind these seeders under most conditions (except wet clays, which puddle readily). The one-way-disc seeder is also limited in its capacity to provide good seed placement by the depth to moist soil and by the amount of soil that can be placed over the seed. The use of the one-way-disc seeder is generally restricted to areas where annual and winter-annual weeds prevail and good weed control can be obtained by one operation. Best results are obtained if previous tillage has left the field surface level. The use of the one-way-disc seeder on stubble frequently maintains a useful quantity of trash (see page 10) and, if reasonable care is taken to avoid excessive soil pulverization, an erosion-resistant field surface is maintained.

Stubble-mulch seeders — Several types of 'stubble-mulch' seeders have been developed for seeding trash-covered fields. These drills utilize either hoe or lister shovel-openers and are mounted on a press-wheel carriage with either the

open-spoke type or, more frequently, the closed-disc type of press wheel. The disc type of wheel creates less dust, is shaped to form a distinct furrow, and does not excessively disturb trash in the ridge between the seed rows. Openers are arranged in either two or three gangs to provide trash clearance.

Seeders equipped with narrow hoe or spear-point furrow-openers, arranged to provide a 7-inch row spacing, can be used under most conditions. Depth of seeding must be carefully adjusted. Seeders with narrow row spacing form only small furrows. The depth that the opener can penetrate to moist soil is generally limited by the amount of soil that can be placed over the seed. Some difficulty may be experienced in obtaining good germination under drought conditions unless seedbeds are firm.

Seeders equipped with wide hoe openers or narrow lister shovel openers arranged to provide a row spacing in the range from 8 to 10 inches place seed in bands about 2 inches wide. These openers can penetrate to a depth of about 4 inches to place seed into moist soil. Some soil is moved into the ridges. Moderate-sized furrows so formed decrease the depth of soil over the seed. These semideep-furrow drills have provided better germination and emergence of the crop under drought conditions than drills with closer row spacing.

Seeders equipped with wide lister shovel openers arranged to give a 12- or a 14-inch row spacing can penetrate to depths of 6 inches to reach moisture without excessively covering seed of cereal crops. Deep furrows are formed and good germination is usually assured under drought conditions. The deep-furrow drill is mainly used for seeding a fall-sown crop such as winter wheat.

Stubble-mulch drills can be used for seeding fallow or stubble land. They will seed through quantities of trash as large as can be managed by the one-way-disc seeder if the trash is uniformly spread and straw length is not over 12 inches. Units with wide-spaced rows have greater trash clearance than units with narrow-spaced rows.

MINIMUM TILLAGE FOR WEED CONTROL

Land is left fallow to control weeds and to conserve moisture. Cultivate early to control weeds in dry regions. Subsequent tillage should be carried out only as needed to control weeds. Herbicides are available to control many weeds in fallow and crop land. Research has shown that a suitable herbicide may be satisfactorily employed as a partial substitute for tillage on fallow land. A herbicide helps to conserve trash by eliminating one or more tillage operations and it is particularly effective as a final fall treatment when tillage might expose soil to movement by wind.

The cultural control of perennial weeds calls for frequent tillage to starve established root systems. This intensive tillage almost completely destroys trash cover and often exposes soil to erosion. A suitable chemical kills weeds and reduces the required number of tillage operations. Leave a cloddy field surface at the end of the tillage program. Use emergency tillage (see page 19) if erosion starts. Consider using a cover crop (see page 18) after the tillage pro-

gram is complete, particularly on soils that are susceptible to erosion.

In years of prolonged or temporary drought it is useful to permit weeds and volunteer grain that germinate late in the summer to continue growth until killed by frost rather than to expose the soil to drifting by late tillage. Except in the very dry areas, plants left until they have attained a height of 8 to 10 inches usually trap sufficient snow to replace the moisture used. Excessive growth may reduce subsequent crop yields (see "Cover Crops," page 18).

STRIP CROPPING

The practice of farming land in narrow strips on which the crop, grain or forage alternates with trash-cover summer fallow is an effective aid in controlling erosion (see Figure 6). It has been used with good results in the drier prairie regions for nearly 50 years.

Strip cropping reduces erosion damage in the following ways:

- It reduces wind velocity across the strip during periods when adjacent fields are covered with tall stubble or tall crops.
- It localizes drifting that starts from a focal point.
- It reduces the distance the wind travels across exposed soil, thus reducing the cumulative effect of soil movement.

Figure 6. Strip cropping and contour farming are usefully employed on the prairies for erosion protection. Light patches of soil on the fields provide evidence of past erosion and the need for continued protection.

Strips must be arranged at right angles to the prevailing wind. They are most effective against wind blowing directly across them but also provide some protection from winds that blow at angles less than perpendicular to the strips. The most effective width of strip depends on soil texture, whether or not the field has been eroded severely in the past, and the prevalence of high-velocity winds in the area. Under some conditions strips should be narrower than the widths given below. Suggested widths for use on soils of different textural classification and farmed in a 2-year rotation are as follows:

SOIL TEXTURE	STRIP WIDTH (RODS)	NUMBER OF STRIPS IN A QUARTER SECTION
Fine sand, fine sandy loam	5	32
Heavy clay	5	32
Silty clay	10	16
Loam, silt loam	16	10
Clay loam, silty clay loam	20	8

When a 3-year rotation is used, select strip widths about equal to those given above for various soils but which pro-

Figure 7. This oat cover crop provided excellent feed and protection from erosion. Pasturing has just started.

vide a number of strips in a quarter section divisible by 3.

The width of a fallow strip may be reduced temporarily by seeding one or two drill widths of a cereal crop through the center at time of spring seeding or in August as a cover crop.

In moist areas erosion occurs from water as well as from wind. Contour strip farming, in which field strips follow the contour of the land, controls both forms of erosion. It is effective on slopes up to about 10 percent. Ridges formed by tillage and by the crop provide barriers against erosion.

Strip cropping is an important aid in controlling erosion. Its value, particularly during drought years, far outweighs the inconvenience of cultivating narrow fields.

COVER CROPS

Cover crop (see Figure 7) is usually defined as a crop, generally cereals, seeded in midsummer on summer-fallow land for erosion control and, if growth is abundant, for fall pasture.

Cover crops are well suited for use in the Black and Grey Wooded soil zones of all Prairie Provinces. They are not generally suited for use in the Brown soil zone and the drier areas of the Dark Brown soil zone as yields of the subsequent crop may be depressed.

Oats are the preferred cereal crop because they are more resistant to attack by aphids than other cereals, and disease is seldom a problem. Oat cover crop can withstand light frost and it recovers quickly from grazing. Satisfactory erosion control can be obtained if oats are seeded at ½ to ¾ bushels per acre. If pasture is also desired, seed oats at a heavier rate (1 to 1½ bushels). Seed cover crop about mid-July if intended for fall pasture and about mid-August for erosion control only. In the northern areas slightly earlier dates may be advisable.

Research has shown that forage yields of 1 ton or more per acre can be produced from oats seeded on fallow in mid-July. This production has been sufficient to pasture one beef animal per acre for a 6-week period beginning when the crop is between the stooling and early heading stage. Average daily gains of 1½ to 2½ pounds have been measured. Gains are usually less under adverse weather conditions than under good grazing and growing conditions. The value of feed produced by cover crop far outweighs the slight loss of crop the next year. This loss arises from some use of moisture and plant nutrients and is most noticeable if the cover crop is seeded early.

Cover crops should not be overgrazed, otherwise erosion can occur. If used for pasturing sheep, move the animals from area to area frequently. The close grazing habit of sheep can quickly denude an area.

Alternate drill widths of cover crop provide protection for fields where special measures are needed against erosion. Cover crop can be used to protect erosion-susceptible knolls or other areas where protective cover has been lost. Volunteer grain and weeds can be utilized in any area, but if growth of this material is not stopped by frost, the field should be tilled with a subsurface cultivator after the plants reach a height of 8 to 10 inches. Late volunteer growth should be left to be killed by frost if

tillage is likely to predispose the soil to erosion. In drier areas cover crop will deplete moisture, and this may not always be made up by moisture from trapped snow and from spring rains. In areas where winter wheat is grown the use of volunteer grain as a protective cover in the fall may increase the incidence of plant diseases, such as wheat streak mosaic, in adjacent fields of winter wheat. Consult local agricultural authorities on this problem.

ROTATIONS

In the Black and the Gray Wooded soil zones the use of summer fallow for moisture conservation is of doubtful value. Rotations involving cereals, grass and legume mixtures, and other crops have given greater production than a fallow-grain rotation. Rotations involving grasses and legumes have controlled weeds more effectively than summer fallow. Studies conducted on experimental farms in the Black soil zone have demonstrated the value of well-planned rotations. Consult local agricultural authorities when planning rotations for your farm.

In the Dark Brown soil zone a 2-year crop-fallow rotation is commonly used. A 3-year rotation consisting of 1 year in fallow and 2 years in crop can often be used to advantage. In some years the stubble crop may produce insufficient trash for protection of the fallowed land. Special attention to fallowing practices is needed to prevent erosion. A grass or a legume can often be used to advantage in the moister areas of this soil zone.

In the Brown soil zone cropping every other year is generally practiced. Summer-fallowing for moisture conservation is essential for maximum production. Some sandy soils are capable of storing only small quantities of moisture during the fallow year. These soils erode readily and continuous cropping to grain or seeding to grass for pasture may be advisable.

SHELTERBELTS

The establishment of permanent tree shelterbelts aids in the control of erosion by wind. Farmstead shelterbelts provide wind protection for the home. Field shelterbelt plantings established in 1935 at Aneroid and Conquest in Saskatchewan and at Lyleton, Manitoba, have been considered helpful in preventing soil drifting.

Well-managed shelterbelts influence wind velocity downwind for distances up to 20 to 30 times the height of the belt. Sufficient reduction in wind velocity to prevent drifting usually occurs for a distance downwind of about 10 times the height of the belt. The degree of protection provided depends on height and density of the belt and on the velocity and direction of the wind.

EMERGENCY CONTROL MEASURES

Drifting once started can usually be stopped, or the intensity reduced, by carrying out an emergency practice suited to soil conditions. Examine fields before deciding on emergency measures to be used and start before too much soil is lost. Always begin on the windward side of the field.

Practices that can be used include the following:

- Chiseling to produce a rough, cloddy soil surface. The spacing of the

chisels will depend on soil conditions and may vary from 1 to 6 feet.

- Strip listing, that is, forming lister furrows at intervals of 5 to 20 feet and at right angles to the wind.
- Complete listing to form deep lister furrows spaced about 3 feet apart with cloddy soil thrown over the ridges. These ridges should be rounded rather than sharply peaked.
- Ridging, that is, roughening the soil surface with cultivator shovels to provide protection with clods and small furrows.
- Plowing or discing to turn under pulverized soil and provide a rough, cloddy surface.
- Applying straw or manure as a surface cover at focal points to stop the spread of drifting. The straw should be disced lightly to anchor it into the soil.

Typical situations and suggested emergency control methods are as follows:

- When the soil is fairly firm and moist but drifting is from a thin, dry layer of surface soil, use any implement that will roughen the surface and

Figure 8. Chiseling to stop drifting. Chisels are spaced about 2 feet apart and placed so that clods are brought up in wheel marks to cover soil pulverized by the wheels.

Figure 9. Cloddy surface after complete listing. Lister shovels were used on a cultivator. Note that ridges are fairly flat and are covered with clods. This work was done in mid-January.

produce clods. Chisels spaced 2 or 3 feet apart and operated just deep enough to produce clods can be used if protection is desired for a considerable length of time (see Figure 8). Strip listing gives protection for a shorter period of time, that is, a week or two before seedbed preparation is begun. Ridging may be considered an alternative to strip listing if control is required just before beginning seedbed preparation. These methods work on loam soils and to a lesser extent on heavy clay but should not be used on sands unless the sandy soil is very firm and moist.

- When the soil is loose, dry, and cloddy within the cultivated layer but the surface has been broken down and drifting has just started, ridging with normally spaced cultivator shovels provides a rough, cloddy surface. Normal tillage breaks down sandy soils and increases rather than controls drifting.

- When the cultivated layer of soil is finely granulated almost to the depth of tillage, complete listing may be necessary (see Figure 9). Operate lister shovels deep enough to penetrate into firm soil beneath the surface material. If lister furrows become filled with drift soil, repeat the operation, forming new furrows between the old. The listing method is one of the few measures satisfactory for use on fine

sandy soils that are in a loosened condition and where long-time protection is required.

- When the surface of the field has developed a sandy, hummocky appearance, till it lightly to level out the piles and follow immediately with a plow or one-way disc to bury and incorporate the sand. This method should be applied to drifted fields immediately before seeding to bury drift soil; otherwise, drifting may start again and injure the crop.
- When soil is frozen but has thawed sufficiently to permit drifting, determine the depth of unfrozen soil. If there are 3 or more inches of unfrozen soil, use chisels spaced 12 or 24 inches apart and operate at moderate speed to permit the chisels to penetrate into the partly frozen soil. Alternatively, use chisel blades on a wide-blade cultivator (Figure 10), weight the machine heavily to force it into partly frozen soil, and chisel at spacings not wider than 5 to 6 feet. If necessary, straddle the last kerf mark on every other width to narrow the spacing. Another way is to use the frozen-soil lister made up from a one-way disc with three out of every four pans removed (Figure 11). If the soil has thawed to a depth of less than 2 inches, use the wide-blade cultivator equipped with chisel

Figure 10. Strip listing to stop winter drifting. A heavily weighted wide-blade cultivator was used and was equipped with a chisel blade, 6 inches wide, on each standard (see inset). Note clods of frozen soil.

Figure 11. A good job of windproofing soil in the wintertime with a one-way disc converted into a lister (upper picture). Note the drifted field surface (lower left) and clods of frozen soil (lower right).

blades or the one-way disc converted for listing. The tandem disc or conventional out-throw disc weighted and operated slow enough to penetrate has been used successfully on frozen soils.

- When drifting starts after the grain crop has germinated and emerged, cover focal points with straw or manure immediately. If these materials are not available, or if drifting is widespread, use chisels spaced about 5 feet apart. If conditions are extreme, use deep strip listing. Some crop will be destroyed, depending on age of plant and severity of the work, but usually the loss of crop will be offset by the soil saved and by the loss in yield that can result from late reseeding of the crop.
- When drifting occurs on a field planted to a row crop, chisel between the rows. Alternatively, use discs on the row-crop cultivator to form a ridge. If in an irrigated area, use furrowing shovels and irrigate as soon as water is available.

soil drifting on irrigated land

Soil drifting is a problem every year on irrigated land, particularly in southern Alberta, where warm, westerly winds create a winter drifting hazard. Many of the annual crops grown under irrigation do not produce sufficient trash to protect the soil during the late fall, winter, and early spring. The practice of pasturing cattle or sheep on beet tops often predisposes the soil to drifting. Fine-seeded crops such as sugar beets and some vegetables need a firm but fine seedbed, which may be susceptible to erosion.

Unprotected land, except sandy and heavy clay soils, should be plowed in the fall (Figure 13) and left in this condition over winter. Additional work such as discing and float leveling should not be carried out before spring unless excellent clod structure can be re-established by a final tillage operation. Where beet tops and corn stovers are pastured off, fall plowing may not be practical and emergency control measures may be needed. Sandy and heavy clay soils should be left in a firm condition over winter and emergency measures used where necessary. *Do not fall-plow these soils.*

Spring preparation of land often calls for float leveling. This firms the soil but may leave a powdery and erosive surface. Except on sandy soils, a harrow behind the float is usually helpful in bringing small clods to the surface. Light tillage after floating may be useful on all soils if they are fairly moist. If drifting has occurred, it may be necessary to spring-plow the land to bury drift soil.

Protective planting of row crops may be used on sandy soils that are dry and erosive or on other soils that are in a hazardous condition. Prepare a firm seedbed for fine-seeded crops. Equip the planter with furrowing shovels and form irrigation furrows as the crop is planted. Irrigate as soon as water is available. On sandy soil, if early culti-

Figure 12. Cultivator tools for stopping soil drifting. Shovel (left), for use when normal tillage or moderate listing is desired. Chisel point (center), for use in frosted soil or in shallow, firm soil that will produce clods. Lister shovel (right), for use where deep work and wide lister furrows are required.

Figure 13. A medium-textured soil moldboard-plowed and packed in the fall and left in a rough, cloddy condition for the winter. Only 10 percent of the surface clods are of the erodible size (see inset with 6-inch ruler).

vation is needed before the crop attains sufficient growth to protect the soil, cultivate, irrigate, and cultivate again while the soil is moist. These operations re-establish a protective cloddy furrow or ridge between the rows. Continue this procedure until the crop provides protection for the soil.

When potatoes are planted, the ridge formed by the covering discs on the planter provides wind protection if care is taken not to pulverize the soil unduly during seedbed preparation. Protective planting can be used when planting corn and other large-seeded crops.

Trash-cover farming (see page10) can be used to some extent on irrigated land. Stubble from cereal crops and stalks from sweet corn and sunflowers should be left standing over winter for the protection of soils unsafe for fall plowing. Stubble from silage corn provides some protection, but on light soils emergency tillage may be required. Grasses and legumes can be seeded directly into clean stubble with good results on soils that erode readily.

specialty crops

Crops such as rape and mustard do not produce enough trash cover to provide protection for the soil and the residue breaks down rapidly. Flax residue, although resistant to breakdown, usually is too small in quantity to protect soil. Summer fallow after these crops have been grown must be care-

fully done to preserve a cloddy, wind-resistant surface. Many farmers prefer to stubble-in a grain crop following these crops rather than to expose the soil to erosion.

Potato tops are of little value for erosion protection. However, harvesting usually leaves fields with a rough surface. Except for sand, these fields have caused little difficulty.

Sunflower stalks may not provide adequate protection for some soils. These stalks are hard to work into the soil. Chopping with either a disc or a shredder that scatters the material over the soil increases protection against wind. It also facilitates subsequent tillage.

pasture and rangeland

Soil drifting is not usually a problem on grass lands that are well managed. However, plant cover can be reduced severely by overgrazing and prolonged drought, and erosion can occur. Avoid overgrazing and, if areas of fine sand, knolls, and places where there is heavy traffic start to drift, use straw or manure to check drifting. Reseed if the area becomes badly denuded.

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CONVERSION FACTORS FOR METRIC SYSTEM

Imperial units	Approximate conversion factor	Results in:	
LINEAR			
inch	x 25	**millimetre**	**(mm)**
foot	x 30	**centimetre**	**(cm)**
yard	x 0.9	**metre**	**(m)**
mile	x 1.6	**kilometre**	**(km)**
AREA			
square inch	x 6.5	**square centimetre**	**(cm^2)**
square foot	x 0.09	**square metre**	**(m^2)**
acre	x 0.40	**hectare**	**(ha)**
VOLUME			
cubic inch	x 16	**cubic centimetre**	**(cm^3)**
cubic foot	x 28	**cubic decimetre**	**(dm^3)**
cubic yard	x 0.8	**cubic metre**	**(m^3)**
fluid ounce	x 28	**millilitre**	**(mℓ)**
pint	x 0.57	**litre**	**(ℓ)**
quart	x 1.1	**litre**	**(ℓ)**
gallon	x 4.5	**litre**	**(ℓ)**
bushel	x 0.36	**hectolitre**	**(hℓ)**
WEIGHT			
ounce	x 28	**gram**	**(g)**
pound	x 0.45	**kilogram**	**(kg)**
short ton (2000 lb)	x 0.9	**tonne**	**(t)**
TEMPERATURE			
degree fahrenheit	°F-32 x 0.56 (or °F-32 x 5/9)	**degree Celsius**	**(°C)**
PRESSURE			
pounds per square inch	x 6.9	**kilopascal**	**(kPa)**
POWER			
horsepower	x 746	**watt**	**(W)**
	x 0.75	**kilowatt**	**(kW)**
SPEED			
feet per second	x 0.30	**metres per second**	**(m/s)**
miles per hour	x 1.6	**kilometres per hour**	**(km/h)**
AGRICULTURE			
bushels per acre	x 0.90	**hectolitres per hectare**	**(hℓ/ha)**
gallons per acre	x 11.23	**litres per hectare**	**(ℓ/ha)**
quarts per acre	x 2.8	**litres per hectare**	**(ℓ/ha)**
pints per acre	x 1.4	**litres per hectare**	**(ℓ/ha)**
fluid ounces per acre	x 70	**millilitres per hectare**	**(mℓ/ha)**
tons per acre	x 2.24	**tonnes per hectare**	**(t/ha)**
pounds per acre	x 1.12	**kilograms per hectare**	**(kg/ha)**
ounces per acre	x 70	**grams per hectare**	**(g/ha)**
plants per acre	x 2.47	**plants per hectare**	**(plants/ha)**

Examples: 2 miles x 1.6 = 32 km; 15 bu/ac x 0.90 = 13.5 hℓ/ha